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PROGRAMMABLE POWER CONVERTER

5 CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from and is a continuation-in-part of U.S. Patent application Serial Number 10/384,263 filed March 7, 2003, which is a continuation-in-part of U.S. Serial Number 10/225,933 filed August 22, 2002, which is a continuation-in-part of U.S. Patent application Serial No. 10/159,910
10 filed May 31, 2002, which is a continuation-in-part of U.S. Patent application Serial No. 10/005,961 filed December 3, 2001, and also is a continuation-in-part of U.S. Patent application Serial No. 10/072,074 filed February 8, 2002, the teachings of which are incorporated herein by reference. In addition, this application claims priority of copending U.S. Provisional Application No. (TBD),
15 filed on July 2, 2003 titled "REMOTELY PROGRAMMABLE POWER CONVERTER", filed by express mail number EV 329715761US, and incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

The present invention generally relates to the field of power converters,
20 and, more particularly, to programmable power converters.

BACKGROUND OF THE INVENTION

As the use of mobile electronic products continues to increase, such as PC notebooks, PDAs, cellular telephones, MP3 players and the like, the need for low cost, compact power supplies and solutions to power and recharge these

products also continues to increase. Most manufacturers of mobile products typically provide plug-in power adapters along with these mobile products to help provide the power supply needs of their customers.

Today's power adapters are typically AC-to-DC, or DC-to-DC power
5 converters which are configured to convert an AC voltage to a DC voltage, or
step-up or step-down the DC voltage input delivered to the mobile device. With
AC-to-DC adapters, for example, users can power most mobile devices by simply
plugging the adapter into a standard AC wall outlet commonly found in most
homes and offices. Similarly, when only DC input power is available, such as in
10 an automobile or airplane, users can still power their mobile devices by simply
using a standard, off-the-shelf DC-to-DC adapter, such as with a cigarette lighter
connector. Normally, both adapters are designed and tailored to provide a
regulated DC output voltage, which voltage typically ranges from between 5VDC
to 30VDC depending on the power requirements of mobile device being powered.

15 Although these power adapters conveniently provide direct power and
recharging capabilities, users are often required to carry separate adapters to
provide power to each individual mobile device. This often means that users have
to carry multiple adapters for each device: one for an AC input power source, and
another for a DC input power source. Moreover, users with multiple devices are
20 typically required to carry multiple adapters to power all the multiple devices,
thereby increasing the amount of bulk a user is required to carry, which is also
tedious.

Accordingly, there exists a need for a power converter and system that
resolves the system power management problems associated with carrying all of
25 the different power supply components necessary to power a wide variety of
mobile and portable devices having different power requirements. Moreover,

there is a need for a power converter and system that is programmable for providing power with selected electrical characteristics.

SUMMARY OF THE INVENTION

The present invention achieves technical advantages as a programmable converter supplying programmable DC voltages adapted to power a plurality of portable devices. In one embodiment of the invention, the converter receives a DC
5 input signal or AC input signal, and provides a predetermined DC output signal, and includes circuitry responsive to the DC signal or AC input signal for providing a converted DC signal in which the converted DC signal has electrical characteristics which are selectable, and includes a controller cooperable with the circuitry for establishing the electrical characteristics based on a selection code.

10 In another embodiment, the converter includes a coupler coupled to the circuitry in which the programming circuitry includes a socket adapted to receive a insertable memory device and electrically couple the programming circuitry and the memory device. The memory device for storing a code indicative of an electrical characteristic selection, wherein the code is readable from the memory by the
15 programming circuitry for imposing the electrical characteristic selection upon the converted DC signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the invention and the specific embodiments will be understood by those of ordinary skill in the art by reference to the following detailed description of preferred embodiments taken in conjunction with the drawings, in which:

Figure 1A shows a block diagram of a dual input AC and DC power converter having dual DC voltage outputs in accordance with the present invention;

Figure 1B shows an exploded view of the converter with the detachable buck circuit;

Figure 2 shows a schematic diagram of the power converter circuit as illustrated in Figure 1 in accordance with the present invention;

Figure 3 shows a detailed schematic diagram of a DC-to-DC buck converter circuit in accordance with the present invention;

Figure 4 is a perspective view of a power converter system including a power converter adapted to receive both an AC and DC voltage input, and a peripheral power hub (PPH) according to the present invention;

Figure 5 is an electrical block diagram of one preferred embodiment of the PPH shown in Figure 4, where each of the outputs of the PPH are connectable to an associated selectively attachable buck circuit providing a selectable voltage to an associated remote device;

Figure 6 is an electrical block diagram of another preferred embodiment whereby the PPH includes a plurality of programmable buck circuits, each having a selectively removable programming device, shown as a resistor R1, whereby each remote mobile device can be directly coupled to a PPH output as shown;
5 and

Figure 7 illustrates a block diagram of a dual input AC and DC power converter having DC voltage outputs in accordance with exemplary embodiments of the present invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The numerous innovative teachings of the present applications will be described with particular reference to the presently preferred exemplary embodiments. However, it should be understood that this class of embodiments provides only a few examples of the many advantageous uses and innovative teachings herein. In general, statements made in the specification of the present application do not necessarily delimit any of the various claimed inventions. Moreover, some statements may apply to some inventive features, but not to others.

10 There is shown in Figure 1A a block diagram of a dual input AC/DC power converter 10 having dual programmable DC voltage outputs in accordance with the present invention. Preferably, the dual input AC/DC power converter 10 comprises a power converter circuit 20 having an AC-to-DC converter 22, a DC-to-DC booster converter 24, a feedback circuit 26, a filter circuit 25 and a DC-to-DC buck converter 28. The power converter circuit 20 is seen housed in housing 13 and advantageously provides a first programmable DC output voltage at DC output terminal 16 and a second programmable DC output voltage at terminal 18. Both of these DC output voltages may be generated as a function of both AC and DC input voltages.

20 In operation, the AC-to-DC converter 22 receives an AC signal via input terminal 12 and provides a regulated DC output voltage at node N1. Similarly, the DC-to-DC booster converter 24 may receive a DC input voltage at its input via input terminal 14 and may also provide a regulated DC output voltage at node N1.

25 Input terminals 12 and 14 are integrated into a single common connector 17 such that different power cords adapted to receive input power from different sources are received by the common connector 17. For instance, DC power from

an airplane or car power source are wired to couple to input 14 and AC source is wired to couple to input 12. In a selected embodiment, the AC-to-DC converter 22 is adapted to generate a DC output voltage of between 15VDC and 24VDC in response to an AC input voltage at terminal 12 ranging between 90VAC and

5 265VAC. Likewise, the DC-to-DC booster converter 24 is adapted to provide a DC output voltage which is substantially similar to that of converter 22, but which is generated in response to a DC input voltage supplied at input terminal 14. Preferably, DC-to-DC booster converter 24 is adapted to receive a voltage in the range of between 11VDC and 16VDC. Advantageously, AC-to-DC conversion,

10 via AC-to-DC converter 22, allows users of the power converter 10 to power high-power mobile devices, such as a laptop computer wherever AC input power is available, such as in the home or office, for example. Conversely, the DC-to-DC booster converter 24 of the power converter 10 is capable of powering similar high-power devices by stepping up most low amplitude DC input signals, such as

15 those found in automobile and/or airplane environments.

As shown, filter circuit 25 has its input tied to the respective outputs of the converter 22 and 24. In a preferred embodiment, the filter circuit is adapted to provide a filtered DC output voltage at second node N2, which, thereafter, feeds output terminal 16, at an output power of 75 watts, for example.

20 The single feedback circuit 26 is shown coupled to the output of filter circuit 25 at node N2. In a preferred embodiment, the feedback 26 circuit, through a single feedback loop, regulates the voltage level of the filtered DC output voltages generated by both converters 22 and 24. Additionally, the feedback circuit 26 is adapted to receive a removable programming module that

25 allows mobile device users to provide a selectable DC output voltage at output 16 via node N2. The programming module comprises a key 15 comprising a resistor, wherein different associated values of the resistor establish different associated

DC output voltages at output 16. By allowing users to selectively change the voltage level of the filtered DC output voltage, the power converter 10 may be adapted to power a variety of different mobile electronic devices, having different associated power requirements. Moreover, the power converter's 10 programming module may also be adapted to provide the additional function of output current limiting.

The DC-to-DC buck converter 28 has its input coupled at node N2, providing a second DC output voltage that is then fed to output terminal 18, having an output power of 10 watts, for example. Preferably, buck converter 28 discreetly steps down the filtered DC voltage and produces a second DC output voltage at a separate output terminal 18. In a selected embodiment, the buck converter 28 steps down the filtered DC output voltage to a range of about 3VDC and 15VDC. Advantageously, this second DC output voltage generated by converter 28 is independent of, and substantially lower than the DC output voltage at terminal 16. This allows users of the present invention to power not only a high-power peripheral, such as a laptop computer, but also, a second, low-power peripheral, such as a cell phone, PDA, and the like. Moreover, the present invention allows for these peripherals to be powered simultaneously by a single converter, regardless if the input voltage is AC or DC. The buck converter 28 is physically detachable from the main housing 13 as shown in Figure 1B, allowing different buck circuits providing different output voltages to be selectively attached to housing 13 and tap the DC output voltage from output terminal 18.

Referring now to Figure 2 there is shown a schematic diagram of the power converter circuit 20 of the dual input AC/DC power converter 10 as depicted in Figure 1 in accordance with an exemplary embodiment of the present invention. As described herein in greater detail, the power converter circuit 20, in

a preferred embodiment, comprises three separate converters: AC-to-DC power converter 22, DC/DC boost converter 24, and DC-to-DC buck converter 28.

AC-TO-DC CONVERTER

The AC-to-DC power converter 22 includes a true off line switcher which
 5 is configured in a fly-back topology. Full-wave rectification of an AC input signal, received at input terminal 12, occurs using a full-wave bridge rectifier BD1 and a filter capacitor C1, which creates a DC voltage bus from which the switcher operates. Inductor L1 offers additional EMI filtering of the AC signal after the signal has been rectified through the full-wave bridge. The AC-to-DC
 10 converter 22 also includes a main controller IC1 configured as a current mode pulse-width modulator (PWM). Main controller IC1 is also configured to have a single-ended output with totem pole driver transistors coupled thereto. The AC-to-DC power converter 22 has a main power switch Q7 which drives the main transformer T1. In a preferred embodiment, the transformer T1, Schottky diode
 15 D11, and filter capacitors C24 and C25 combine to provide the DC output voltage at node N1.

As noted earlier, filter circuit 25 allows for additional filtering of the DC output voltage derived from node N1. The filter circuit 25 itself comprises inductor L3, capacitor C26 and transformer NF1. Advantageously, the filter
 20 circuit 25 produces a filtered DC output voltage at output 16 having less than 100mv peak-to-peak noise and ripple.

The feedback circuit 26, through a single feedback loop, is capable of regulating the filtered DC output voltages provided by the converters 22 and 24. The feedback circuit 26 is also adapted to be coupled to a removable
 25 programming module having a key 15, comprising resistor R53. As such, the

present invention allows users to selectively program the DC output voltage later received at output terminal 16. The feedback circuit 26 includes a photocoupler circuit comprising a pair of photocouplers PH1 and PH3 connected in series (i.e., stacked), each being coupled to the outputs of operational amplifiers IC4-A and IC4-B. Advantageously, these photocouplers are arranged along the feedback loop of the feedback circuit 26 with photocoupler PH1 and PH3 coupled respectively to converters 22 and 24. Through a single feedback loop, the feedback circuit 26 efficiently regulates the filtered DC output voltage provided at node N2. Moreover, by stacking the photo-couplers, the present invention also allows the power converter 10 to maintain proper input/output isolation between respective terminals 12 and 14 and output terminal 16.

Preferably, the output current limiting function of converter 22 is accomplished via integrated circuit IC4A, resistors R33, R37, R38, and R39 and programming resistor R54.

Over voltage protection of AC-to-DC converter 22 is achieved using photocoupler PH2 and zener diode ZD2. In a preferred embodiment, zener diode ZD2 is set at 25V such that when in avalanche mode it causes the transistor side of photocoupler PH2 to bias transistor Q1 into the on state. When it is the on state, transistor Q3 pulls low pin 1 of integrated controller IC1 and pulls the operating duty cycle of the integrated controller towards 0%. This takes the DC output voltage to 0 volts. Also, when transistor Q1 is on, transistor Q2 is also forced on which then forces these two transistors become latched. If transistors Q1 and Q2 are latched, input power must be recycled in order for the power converter 10 to be turned on again.

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DC-TO-DC CONVERTER

The DC-to-DC converter 24 is configured in a boost topology and utilizes the same kind of integrated controller, IC2, as used in converter 22. In the DC-to-DC converter 24, transistor Q8 acts as the main power switch and diode D8 as the main rectifier. Preferably, inductor L2 is adapted to function as a power boost inductor, which is comprised of a toroid core-type inductor. It should be understood that the cathode leads of diodes D11 and D8 are connected, forming an ORed configuration, requiring only one output filter. Advantageously, this eliminates the board space needed for a second set of filter capacitors.

Like the AC-to-DC converter 22, the DC-to-DC converter 24 is also designed to operate at a frequency of around 80KHZ. For the AC-to-DC converter 22, the operating frequency is set by resistor R13 and capacitor C7. Likewise, the operating frequency of the DC-to-DC converter 24 are set by resistor R28 and capacitor C16.

The DC-to-DC converter 24 includes an over-voltage protection circuit comprising zener diode ZD2, resistor R23, R24, R48, transistor Q4, and silicon-controlled rectifier SC1. Zener diode ZD2 sets the over-voltage protection point (OVP) which is preferably set at 25VDC. Generally, there is no current flowing through resistor R48. If, however, when zener diode ZD2 begins to conduct current, the drop across R48 is significant enough to bias transistor Q4 on, pulling its collector terminal high, and thereby turning silicon controlled rectifier SC1 on. When silicon control rectifier SC1 is on, it pulls pin 1 of the integrated controller IC2 low. Thus, if pin 1 of integrated controller IC2 is low, the output drivers thereof are forced to operate at a duty cycle of 0%, thereby producing a DC output

voltage of 0 volts at IC2 pin 6. Advantageously, the silicon controlled rectifier SC1 functions as a power latch circuit that requires that input power be recycled in order to turn on the power converter 10 if a voltage above 25VDC is detected at node N1.

5 The temperature of the housing 13 of the power converter 10 is monitored using a thermistor NTC3. If, for example, there is a corresponding increase in the temperature of the housing 13, it will result in a decrease in the resistive value of thermistor NTC3, thereby causing transistor Q9 to turn on and pull low pin 1 of integrated circuit IC2 of converter 24. Moreover, this causes the photo-coupler
10 PH2 to be biased enough to activate a latch circuit comprising transistors Q1 and Q2 that will shutdown the power converter 22. In addition, the power converter's 10 thermal protection feature is adapted to operate regardless of whether an AC or DC input voltage is being received at their respective input terminals.

Figure 3 shows a detailed schematic diagram of the DC-to-DC buck
15 converter 28 in accordance with the present invention. The buck converter 28 has an integrated circuit controller IC1, similar to converters 22 and 24, which is adapted to generate an on-time duty cycle to power transistor switch Q1. The operating frequency of controller IC1 is set by capacitor C6, which is coupled between pin 4 of IC1 and ground, and resistor R1, which is coupled between pins
20 4 and 8. In a selected embodiment, the diode D1 functions comprises a Schottky diode and functions as "catch" diode. Inductor L1 is a output power inductor and couples the source of power transistor Q1 to V_{out} . Fuse F1 is shown coupled between V_{in} and the drain terminal of power transistor Q1, and advantageously provides current protection to buck-converter 28.

25 Furthermore, the input V_{in} of the buck converter 28 is coupled to the output of filter circuit 25 at node N2, wherein V_{in} receives the filtered DC output

voltage therefrom. In a preferred embodiment, the buck converter 28 provides a second DC output voltage at V_{out} , coupled to output terminal 18. Advantageously, the buck convert 28 discreetly steps down the filtered DC output voltage and provides a second DC output voltage at output terminal 18 which is independent of, and substantially lower than the DC output voltage at output terminal 16. Likewise, the DC output voltage of the buck converter 28 enables users of the present invention to power low-power peripherals, such as, cell phones, PDAs, and/or similar mobile devices. In a selected embodiment, the buck converter 28 may also be adapted to provide a DC output voltage at output terminal 18 ranging between 3VDC and 15VDC, selectively determined as a function of the chosen value of resistor R2 used in the particular buck converter 28, with a total power delivery of 10 watts, for example. As previously mentioned, the buck converter 28 may be housed in a separate, detachable program module that enables users to selectively program the DC output voltage at terminal 18 as a function of different associated buck converter modules.

Referring now to Figure 4, there is generally shown at 40 a perspective view of a peripheral power system (PPS) seen to include the AC/DC-to-programmable DC output converter 42 as shown and described in reference to Figures 1-3. In addition, PPS 40 is also seen to include a peripheral power hub (PPH) shown at 44 and having a plurality of DC voltage outputs generally shown at 46. As will be described in more detail shortly, in one preferred embodiment (Figure 5) predetermined DC voltages are provided at each output which may then be converted by a buck circuit 28 associated with the peripheral device 72 to be powered. In another preferred embodiment (Figure 6) each of these outputs 46 is programmable as a function of a removable programming key, such as a selectively replaceable programming resistor. Converter 42 provides a predetermined output DC voltage, which may be programmable, via a DC voltage

coupler 48 to a primary device, such as a notebook computer 50, requiring a higher operating voltage and consuming a large amount of power, such as 45 watts. DC voltage coupler 48 also provides tapping of this output DC voltage provided to the primary device 50, which voltage is tapped via a connector 52.

5 In the embodiment shown at 60 in Figure 5, the input voltage provided to input 62 is muxed to the plurality of output ports 46. The separate buck circuits 28 associated with and selectively coupled to the associated remote mobile device 72 convert this voltage to the final output voltages V1-V4 as shown in Figure 5, which meets all the power needs of the associated mobile device 72. According
10 to the embodiment shown at 70 in Figure 6, the plurality of buck circuits 28 are integral to the PPH 44, each buck circuit 28 having a selectively removable programming key, shown as resistor R1, providing a programmable DC voltage to the respective output port 46 commensurate with the requirements of the associated remote mobile 72 device. Output ports 46 may be configured as
15 simple pin type connectors, USB type connectors, and other configurations as desired. Again, the buck circuit 28 could be substituted with a boost circuit if desired to provide a higher voltage.

Turning now to Figure 5, there is shown the first embodiment of the present invention comprising the PPH 44 shown in Figure 4. As previously
20 mentioned, the input DC voltage provided to the PPH 44 at input 62 is coupled to each of the output ports 46 by a voltage mux 64. This coupling of the input DC voltage to the multiple output ports 46 can be accomplished in a number of ways, such as via a simple resistive divide network, and may provide output-to-output isolation. In one implementation, the DC voltage provided at input 62 is directly
25 provided to the output ports 46 for a subsequent down-stepping via the associated buck circuit 28. However, a lower voltage can be provided by the voltage mux 64 to each of the output ports 46 if desired. Voltage mux 64 is also seen to include

an over load protection circuit generally shown at 66 which limits the amount of power that can be provided to each output port 46, such as 7 watts, to prevent overload of the PPH 44, and to prevent power hoarding at one output by its associated remote device 72 to the detriment of the other remote devices 72.

5 Visual indicators 68 are provided to visually indicate the status of each output port 46. For instance, the LED 68 associated with each of the output 46 may be illuminated as green when power provided via output port 46 is below a predetermined limit, such as 7 watts each. If, however, a remote device 72 associated with the particular buck circuit 28 is attempting to draw more than the
10 predetermined limit, the voltage mux 64 prevents providing power in excess of this predetermined limit, and also illuminates the associated LED as red indicating an attempted over power condition. Thus, a user can visually ascertain whether or not power being provided to the associated output port 46 is within an acceptable range as visually indicated by an associated green LED 68, or, that the associated
15 remote device 72 is attempting to draw more than the predetermined limit. The voltage mux 64 also includes a main fuse 69 preventing excessive power draw of the PPH 44 itself, which could otherwise cause an overload condition to the power converter 42 or other input power source.

 The advantages of the embodiment 60 shown in Figure 5 include that a
20 separate buck circuit 28 and the associated cord can be simply coupled to any of the output ports 46 and provide a programmable DC output voltage meeting the needs of the associated remote device 72. A user having a buck circuit 28/cord for use with the particular remote device 72 can be plugged into any of the available output ports 46 of the PPH 44. The DC voltage is stepped down by
25 buck circuit 28 external to the housing of PPH 44. This solution is low cost and a simple design.

Turning now to Figure 6, there is shown at 70 another preferred embodiment of the present invention whereby a plurality of buck circuits 28 are provided within the PPH 44 to provide a programmable output DC voltage to the respective output port 46. Each buck circuit 28, as shown in Figure 3, has an associated programming resistor R1 which may be selectively removable from the PPH 44 to selectively establish the output DC voltage provided to the associated output port 46. Thus, the DC output voltage at each output port 46 is selectively programmable, and a remote device 72 need to only utilize a standard two conductor cord to couple to output port 46, as shown. Namely, one conductor couples the programmable output voltage V1, and the other conductor provides the ground. Again, each buck circuit 28 could be substituted with a boost circuit if desired.

Advantages of this embodiment 70 include that the buck circuits 28 are enclosed in the PPH 44, where each buck circuit 28 itself may be programmable using the associated programming resistor R1. In this arrangement, care must be taken that the remote device 72 is coupled to an output port having a desirable output voltage. Thus, the keys provide indicia of the output voltage being provided. The voltage mux 64 simply provides the input voltage at input 62 to each of the buck circuits 28, which may step down (or step up) the voltage thereat. Voltage mux 64 includes the overload protection circuit 66, the associated LED's 68, and the hub main fuse 69 as shown.

Both embodiments 60 and 70 provide a DC peripheral power hub adapted to power a plurality of unique remote devices 72 from a single unit 44, such remote devices including a cell phone, PDA, MP3 player, etc. This peripheral power hub 44 may be an accessory to power converter 42, or, a stand alone device receiving power. For instance, the input cord 52 feeding PPH 44 may be directly coupled to an output of converter 42, as shown in Figure 4, tapped from the DC

coupler 48 without any down stepping by a buck circuit 28, or directly coupled to a DC source, such as via a cigarette lighter outlet, or other input source.

According to yet another preferred embodiment, as shown in Figure 7, the power converter 10 include programming circuitry 726, such as a micro-controller (computer chip). The programming circuitry 726 is cooperable with converters 22 and 24, and filter 25 for effectuating a program for setting the electrical parameters associated with the output signals 16 and/or 18, such as the output voltage, output current, output power, current limit, polarity, over voltage protection threshold, and/or other electrical parameters associated with each of the output signals 16 and 18. Programming signaling/feedback occurs through communication lines 722 and 724. For example, the converter 10 with a micro controller inside, adjusts the numerical value of sensing resistor(s) or reference voltage(s) (shown in Figures 2 and 3) to effectuate a determined output voltage(s), output current(s) or output power. The programming circuitry 726 can include memory 715 for data and program storage, hardware, and/or software which enables start-up and control for effectuating the above-mentioned electrical properties. In a preferred embodiment, the programming circuitry 726 is powered from the converted signal of either converters 22 or 24.

Data indicative of electrical parameter selection is storable by the programming circuitry 726 in memory 715, such that on a power-up condition the data is read and the associated electrical parameters of the signal output 16 and/or 18 are effectuated by the programming circuitry 726. This data can be programmed into the programming circuitry 726 and subsequently into the memory 715 from outside the power supply unit. That way, by changing the data that is provided to the programming circuitry 715 and memory, the characteristics of the supplied signal can be changed at will. For example, the data can be provided to the programming circuitry 726 at the time of production or by an OEM vendor who might stock

standard power supply units and then program each one for a specific customer's needs. This process would be akin to activating a new cell phone with the customer's information. The data can also be provided by the peripheral device 72 to be powered, such that the device 72 programs the programming circuitry 715 to effectuate electrical parameters required for the device 72.

The data can be provided from a source 710 external to the converter 10 (such as a program controller) via a simple 2 pin connector, infra-red or visible optical signaling, magnetic induction, acoustic signaling, etcetera. Transmission mediums 725 for communication between the external source 710 and the converter 10 include both wired mediums (such as coaxial cable, twisted pair wire, fiber-optic cable) and wireless mediums. The converter 10 can also include an interface 720 for interfacing between the different signaling types and transmission mediums, and the programming circuitry 715. Thus, as can be understood, the converter 10 can be programmed via communication systems such as the Internet to deliver data, analog and/or digital, from an external source to the converter 10.

In yet another exemplary embodiment, the programming circuitry 726 includes an EPROM 715 which forms a portion of the circuitry. The EPROM 715 can be permanently affixed in the converter 10 or selectively insertable into, and removable from an EPROM socket (i.e., keyway). The EPROM is programmed external of the converter 10 (using an EPROM burner, for example), and then inserted into the socket to effect the desired output characteristics. Advantageously, the EPROM chip could be programmed at the time of purchase, and then installed by a salesman into the converter. Advantageously, several EPROM chips can each be programmed for different output characteristics and selected from and inserted as the intended use changes. An EEPROM may also be utilized in place of the EPROM to prevent the need to install different EPROMS for different output programming.

Though the invention has been described with respect to specific preferred embodiments, many variations and modifications will become apparent to those skilled in the art upon reading the present application. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.

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